PRAWN TAGGING EXPERIMENTS IN NEW SOUTH WALES

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(Communicated by Dr. A. A. Racek)

(Plate XXV and Text-figures 1–3)

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Synopsis

An account is given of five field experiments in estuarine and ocean waters of New South Wales, in which an Atkins type tag was attached to 3,358 penaeid prawns, which were subsequently released into their natural habitat. The methods used in these experiments, the percentage of prawns recaptured and the initial mortality due to tagging are described and discussed.

INTRODUCTION

Tagging and marking techniques have been established as important tools in the study of fish populations for nearly a century. Crustaceans, however, are difficult to tag or mark effectively because of the frequent shedding of the exoskeleton at ecdysis, and suitable methods have only been developed over the past fifty years. George (1965) recently described the techniques used in the marking and tagging of various decapod crustaceans. Penaeid prawns have been even more difficult to tag and mark because of their comparatively small size and frequent moulting. Lindner and Anderson (1956) tagged prawns as early as 1934 with Petersen disk tags, but considerable research is still being carried out to develop better tagging and marking techniques, since the Petersen tag is suspected of causing physical damage to the prawns as well as impairing their swimming ability (Dawson, 1957; Allen and Costello, 1963). Menzel (1955) successfully marked *Penaeus setiferus* by injection of a solution of Fast Green vital stain. Dawson (1957) developed this injection technique further, and Costello (1959), and Costello and Allen (1960), successfully demonstrated its use in field experiments.

The stain injection method of marking is rapid, and evidently has no adverse effect on the prawns marked (Klima, 1964), but it has the disadvantage that individuals cannot be distinguished, and for experiments designed to estimate growth all animals released must necessarily be of uniform size. Kourist, Mauch and Tiews (1964), and Tiews (1965), attached small plastic tags to *Crangon* by wrapping thin silver wire around the animal between the carapace and the first abdominal segment. This tagging technique, however, can only be used in short term studies since the majority of tagged animals do not survive for more than 1–2 ecdyses. Allen and Costello (1963) reported that an Atkins tag "may be particularly useful for tagging small-sized shrimp". This is a small plastic tag attached to the animal by a nylon line which is passed through the first abdominal somite with a needle. The Atkins tag is believed to cause less injury to prawns than the Petersen tag, attached to the animals with a nickel pin passing through the abdomen, but unfortunately it was never before used in field experiments. The Atkins tag appeared to be an improvement over the earlier techniques, and laboratory experiments were conducted by the author to test this tag on the King prawn (*Penaeus plebejus*) and the School prawn (*Metapenaeus macleayi*). These experiments showed sufficient promise to warrant evaluation of the Atkins tag in field experiments.

This paper deals with the procedures adopted in five tagging studies of growth and migrations of prawns in the Hunter and Clarence regions in New South Wales. Detailed information on the migrations between release and recapture, days of freedom and growth of tagged prawns will be given in a forthcoming paper (Ruello, M.S.).

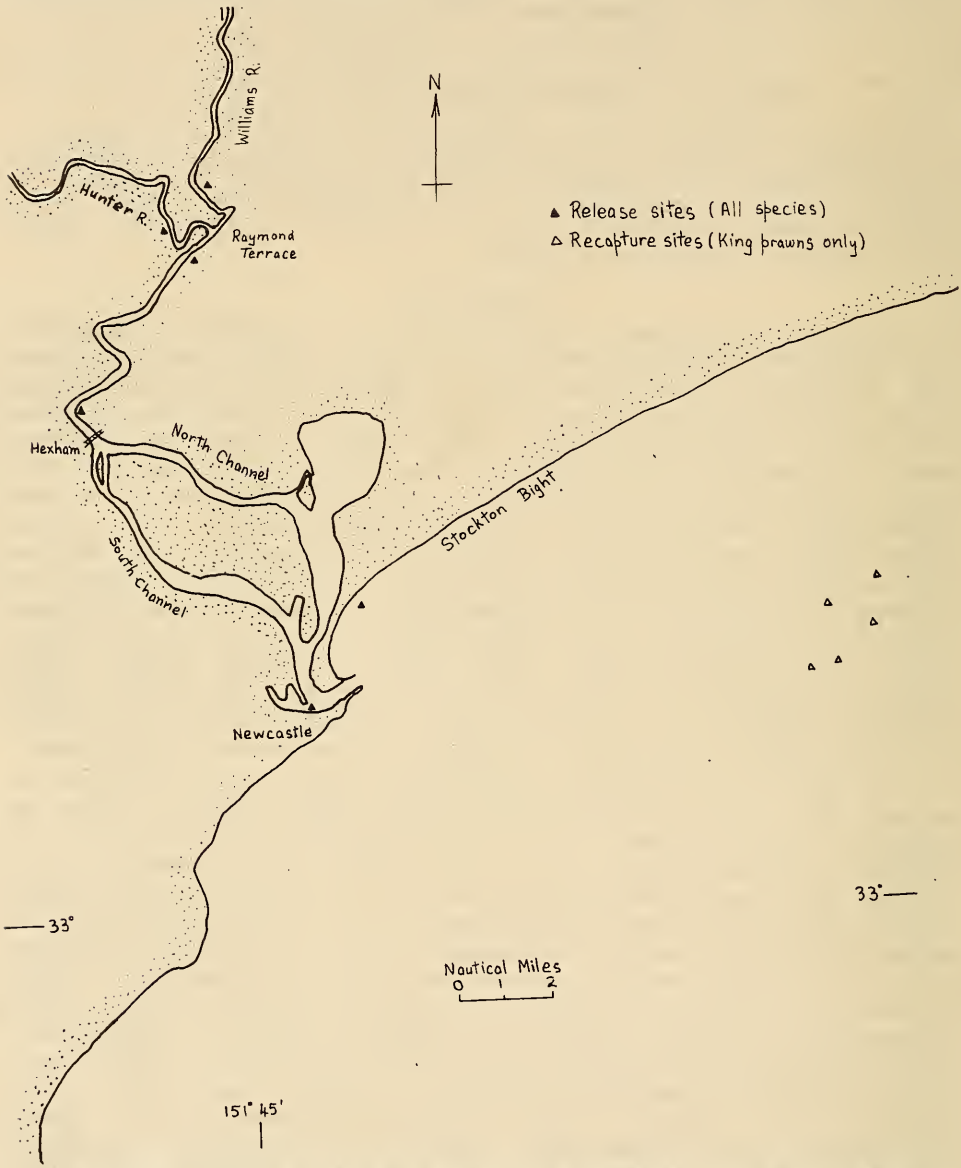

Fig. 1. Map of Hunter region showing the release sites of all species tagged in this area. The recapture sites of the king prawns caught in ocean waters are also marked.

Material and Methods

Atkins tags

These were manufactured from Astralon, a semi-rigid polyvinylchloride material, rectangular in shape, approximately 13·5 mm. long and 6·3 mm. wide and yellow in colour. The words "NSW Fish" were printed on one

side and a serial number on the other. Monofilament nylon fishing line of 3 lb. breaking strain was tied to the punched end of the tag and a loop tied in the free end of the line. The average weight of the tag and line was 0·033 gm. The length of the nylon line will depend on the size of the prawns to be tagged, but a line about 40 mm. long plus a loop about 13 mm. "long" was found to be satisfactory for prawns with carapace lengths from 15 to 25 mm. The knot forming the loop must be pulled tight so that the line passes through the prawn's abdominal tissue with minimal resistance. The tied tags were fixed in plasticine in the numbered compartments of histological slide boxes. These boxes kept the tags safe and in numerical order even in windy conditions (see Plate xxv).

Tagging needles

Ordinary carbon steel nickel plated sewing needles, modified by cutting open the forward part of the eye on an electric grinding wheel, were used in these experiments.

Holding tanks and water pump

Prawns were held in rectangular polyethylene tanks 48″ × 24″ × 24″ and in plastic tanks 21″ × 14″ × 12″. The large tanks were filled and emptied with a Villiers powered 1″ Finsbury pump unit.

Underwater release box

A rectangular plywood box 21″ × 15″ × 10″ standing on 16″ legs with a weighted hinged door on the bottom and a small sliding door on top, was used to release prawns on the bottom. The box was weighted with lead and perforated with ¼″ holes so that it could sink.

Salinity and temperature measurements

Water temperature and salinity in the large holding tanks, and at the site of capture and release of prawns, was measured with an Electronic Switchgear S-T bridge type MC-5.

Length measurements

The length of prawns was determined by measuring the carapace, to the nearest ½ mm., with dial calipers. This procedure was adopted because it was quicker and more reliable than measuring total lengths of prawns.

Capture and selection of prawns

Prawns for tagging were especially caught by commercial fishermen, using trawl and pocket nets* measuring approximately 6 fathoms along the corkline. The duration of each individual fishing operation was restricted as much as possible to minimize injury to prawns after they had entered the net. Lively prawns, with a carapace length of about 15 mm. or greater, were quickly selected from the catch and dropped into the large tanks. These large tanks, containing a foot of water, were used to hold as many as 300 prawns before tagging. Prawns were periodically removed from the large tanks with dipnets and transferred to small plastic tanks on a table, ready for tagging.

* Pocket nets are staked out at night across the stream and trap prawns moving with the tidal current and/or the wash produced by the propeller (and motor) of an anchored vessel.

Location and Date of Experiment

1. Stockton Bight—July 1968

Prawns were captured by trawling, midway along Stockton Bight at a depth of about 15 fathoms on the 3rd and 4th July. School and king prawns were tagged aboard a trawler and later released in Stockton Bight near the Stockton Hospital at a depth of about 7 fathoms (see Fig. 1).

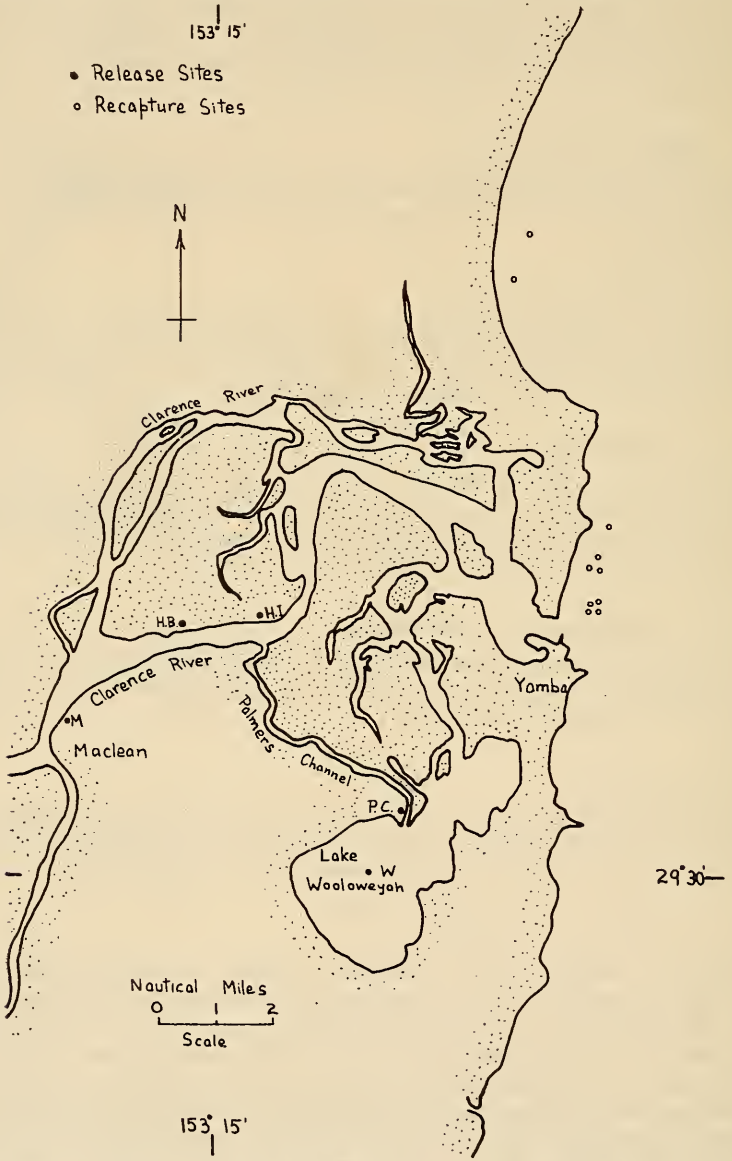

Fig. 2. Map of Clarence region showing the release sites of tagged prawns and the recapture sites of prawns caught in ocean waters.

2. Hunter River—October 1968

School prawns were caught by trawling in the river about 1 mile upstream of the Hexham Bridge on the 16th October. The prawns were tagged aboard a trawler and later released in the same area of the river. The Hunter River

was closed to trawling at this time and commercial fishing did not commence until the 22nd November; three tagged prawns were recaptured in the closed season, however, during routine prawn sampling operations by the Fisheries Department.

3. Clarence River and Lake Wooloweyah—November 1968

A small number of school prawns were caught with pocket nets in the Clarence River on the 5th November; these prawns were tagged on shore and 93 were subsequently released in the river at Maclean. The majority of prawns for this experiment were obtained by trawling in Lake Wooloweyah on the Clarence River on the 6th November. These prawns were tagged on shore and 77 school and 1 king prawn were released in the centre of Lake Wooloweyah, 107 school prawns were released in the southern end of Palmers

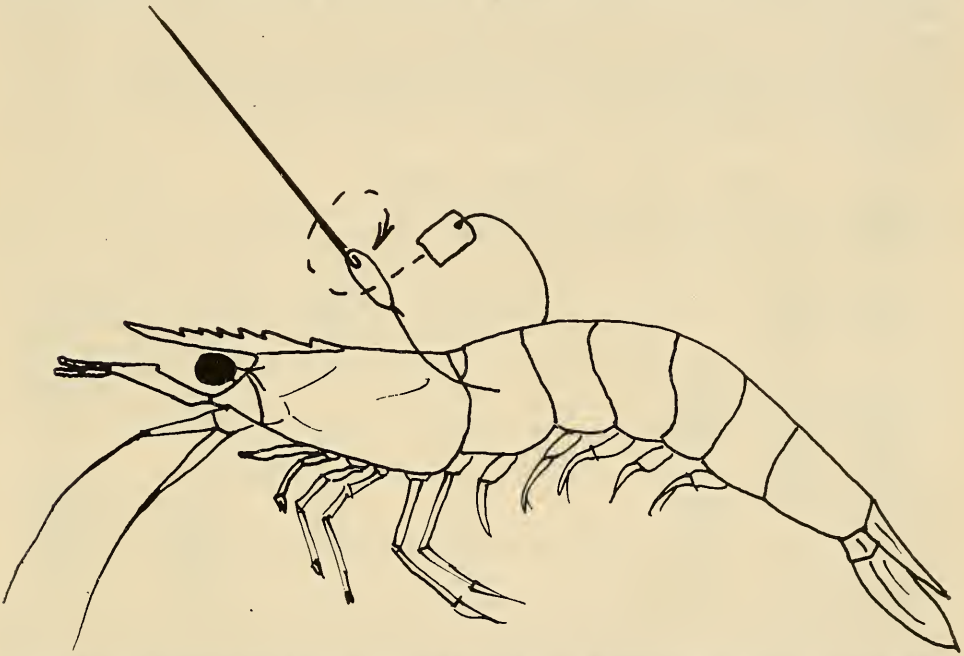

Fig. 3. Method of attachment of Atkins tag to the prawn: The nylon line is passed through the prawns abdomen with a needle, the tag is passed over the prawn and through the loop in the line, twice.

Palmers Channel. On the following day 127 trawled school prawns were Channel and 144 school prawns were released in the Clarence River near tagged and released in the Clarence River near the Harwood Bridge. The Clarence River was closed to prawn trawling at the time of this experiment and trawling did not commence in the river proper, until the 1st December, 1968 (prawn trawling was permitted in Lake Wooloweyah, and prawns could be caught in the river with pocket nets, in November). See Fig. 2.

4. Hunter River—January 1969

Prawns were caught by trawling in Newcastle Harbour, tagged on shore, and subsequently released in the same area. A total of 791 king prawns, 97 school prawns and 2 greasyback prawns (*Metapenaeus bennettae*) were released on the 9th and 10th January; a total of 649 king prawns, 178 school prawns and 2 greasyback prawns were tagged and released on the 16th and 17th January.

5. Hunter and Williams Rivers—March 1969

School prawns were caught by trawling in the Hunter and Williams Rivers near Raymond Terrace. They were tagged on shore and 183 were released in the Williams River about 2 miles upstream of the Hunter River, 169 prawns were released in the Hunter River about 2 miles upstream of Raymond Terrace and 162 prawns were released in the Hunter River about 1 mile downstream of Raymond Terrace.

Tagging and Release Operations

Atkins tags were attached to prawns in the manner described by Allen and Costello (1963). The loop on the end of the nylon line was hooked onto the eye of the needle and the needle passed laterally through the first abdominal somite (avoiding the gut) drawing the loop through the animal (see Fig. 3). The tag was passed over the abdomen and through the loop and then secured by passing it through the loop again. After tagging a prawn, its carapace was measured and sex determined by the presence or absence of a petasma. King prawns were not sexed because of the difficulties involved in rapid sex determination, particularly in smaller individuals of this species.

Table 1

*Comparison of Initial Tagging Mortality at Different Water Temperature and Salinity in Holding Tanks**

Locality and date of experiment	Species	Number tagged	Initial tagging mortality (%)	Water temperature (° C.)	Salinity (‰)
1. Stockton Bight	School	361	0	15–16	34
July, 1968	King	18	0	15–16	34
2. Hunter River	School	193	3·1	20–21	7
October, 1968					
3. Clarence region	School	592	3·5	24–25	23–28
November, 1968	King	2	50·0	24–25	23–28
4. Hunter River	School	293	6·1	23–24	33–35
January, 1969	King	1,472	2·0	23–24	33–35
	Greasyback ..	4	0	23–24	33–35
5. Hunter region	School	548	6·2	24–25	8–9
March, 1969					

* The difference in temperature between the water in the holding tanks and the river or seawater where the prawns were caught and later released was never greater than 1° C.

Female school prawns were also examined for the presence of developing eggs in the ovaries (these are visible through the exoskeleton) and for the presence of spermatophores attached to the thelycum. Different prawn species were identified by the characteristic rostral tooth armature (Racek, 1955). Tagging was normally carried out by a group of three persons, one recording the information dictated by the two others tagging. Thus it was possible to tag an average of 120 prawns per hour. Tagged prawns were dropped into a large polyethylene tank containing about 18 inches of water, and held (in batches of 100) for 2 hours, at the end of which all dead or suspect prawns (those unable to move away when disturbed) were removed and marked off the tagging records. This holding procedure was adopted to provide an estimate of the initial mortality due to tagging. Surviving prawns were transferred from the holding tanks to the underwater release box with dip nets. The box was lowered to the sea bottom on a strong line and the prawns released by pulling on another line which released a sliding bolt lock

and opened the bottom door on the box. Prawns were released on the bottom to prevent the undue losses due to predation by fishes and birds, had they been released at the surface.

Recovery Procedure

Prawns in the release areas and anticipated areas of occurrence were captured almost exclusively by commercial fishermen. Publicity regarding the present tagging experiments was therefore directed more to commercial fishermen than to the general public. Notices outlining the objectives of the experiments and featuring illustrations of a tagged prawn were prominently displayed in Fishermen's Co-operatives and State Fisheries Inspectors' offices in New South Wales. These notices requested fishermen to record the tag number and other relevant information immediately after capture of tagged prawns and to return them to the nearest Fisheries office without delay.

Table 2

Summary of Release and Recapture Data from Prawn Tagging Experiments

Locality and date of experiment	Species	Number released	Percentage recaptured	Days freedom			Average increment in carapace length (mm.)
				Min.	Max.	Av.	
1. Stockton Bight July, 1968	School ..	361	8·3	0	163	25·8	0·42
	King ..	18	0	—	—	—	—
2. Hunter River October, 1968	School ..	187	6·4	16	69	37·9	3·75
3. Clarence region November, 1968	School ..	558	4·3	1	28	7·6	0·20
	King ..	1	0	—	—	—	—
4. Hunter River January, 1969	School ..	275	9·8	1	73	17·2	0·22
	King ..	1,440	2·4	1	52	15·8	0·68
	Greasyback	4	25·0	21	21	21·0	0
5. Hunter region March, 1969.	School ..	514	31·7*	0	26	6·8	0·13

* This includes 1% verified recaptured but not returned.

Commercial fishermen in the Hunter and Clarence regions were also shown samples of tagged prawns and given copies of publicity notices before tagged prawns were released. A reward of 40 cents was offered for the return of each tagged prawn together with information on the time and place of capture. These experiments also received considerable publicity on television, radio and in the local press, so that it can be assumed that all commercial fishermen in the Hunter and Clarence regions were aware of the tagging experiments. The Fisheries Inspectors at Newcastle and Maclean received tagged prawns and preserved them in 5% neutral formalin and maintained records of the tag number, species, time and place of capture and other information given by fishermen. Tagged prawns were periodically collected by the author, examined, and checked against tagging records, to ensure that the tags had not been removed and replaced on another prawn. No attempts were made to substitute prawns in the present experiments though Lindner and Anderson (1956) reported that a few attempts were made to substitute animals in their experiments. Prawn fishermen in the Hunter region were approached personally or by mail, two months after the experiment in March 1969 and asked to report any tagged prawns recaptured but not returned to this Department. This approach was rewarded as 1 per cent of the prawns released were later reported to have been captured but

not returned for various reasons: four tagged prawns were lost when one fishing vessel caught fire, one prawn was taken from a fishing vessel by a seagull, and one prawn fell victim to a cat.

Measurement of Recaptured Prawns

Since all tagged prawns returned were subsequently measured by the author a test was conducted to see if there were differences in the carapace measurements obtained by the author and those obtained by others: Each person involved in the tagging operations measured 50 king prawns in the usual manner, and their measurements were compared with those of the author's but no significant differences were detected.

The following experiments were conducted to study the effects of the various handling procedures, normally adopted by commercial fishermen, on the carapace measurements of prawns: Fifty king prawns were tagged, kept in the shade for 2 hours before being cooked (by boiling) and then allowed to cool for 2 hours before they were put into 5% neutral formalin. Another 50 king prawns were cooked immediately after tagging, cooled for 2 hours then put into formalin. Carapace measurements of these prawns were taken after each step and after 3 weeks in formalin. This experiment revealed that there were no significant differences in the carapace lengths of the prawns at any stage in the handling procedure or after their submersion in formalin. It was assumed that the results of the above experiments were applicable to the other species tagged. The carapace length of all prawns returned was determined to the nearest $\frac{1}{2}$ mm., but a positive or negative change of $\frac{1}{2}$ mm. was considered insignificant because of the low precision involved in the carapace measurements, and was therefore treated as zero change for growth studies.

Results and Discussion

A summary of the results of the five experiments is presented in Tables 1 and 2. Tagged prawns were recaptured by commercial fishermen in the Hunter and Clarence regions. Fishermen apparently had little difficulty in detecting tagged prawns because 95% of those returned were detected before the catch was cooked on board the vessel. Only 2 tagged prawns, representing less than 1 per cent of those returned, completely escaped detection by fishermen and were subsequently returned by a housewife and a fish merchant. Although a few of the tags returned were covered with mud, none were covered with fouling organisms.

The only apparent deleterious effect of the application of the Atkins tag was a small dark lesion in the exoskeleton and superficial abdominal muscles around the tagging puncture. Such injuries could possibly be reduced by treating the nylon line on the tag and the tagging needle with an antibiotic before use. Larger lesions are, however, occasionally found on prawns in natural populations.

Approximately a third of the 548 tagged school prawns released in the Hunter and the Williams rivers in March 1969 were recaptured further downstream in the Hunter River within 26 days of their release. Some of the tagged prawns presumably would have left the river on their spawning migration (Racek, 1959; Ruello, 1969) and others would have died from causes other than fishing. Costello and Allen (1968), in a study of the mortality rates of the pink shrimp *Penaeus duorarum* in Florida, estimated that the loss in the population over a two week period, due to all causes other than fishing, was 19·7 per cent on the Tortugas grounds and 14·8 per cent on the Sanibel grounds. Assuming that the mortality rates in the school prawn populations

in the Hunter region are similar, the high recapture rate in experiment 5 suggests that the Atkins tag does not have much adverse effect on the survival of prawns released in their natural environment.

The initial tagging mortality* of zero in the Stockton Bight experiment was presumably due to the low temperature of the water in the holding tanks and the prevailing low sea temperature. Reference to Table 1 reveals that the initial tagging mortality of school prawns increases with water temperatures. The initial tagging mortality in school prawns was significantly higher than that in king prawns in the Hunter River experiment in January 1969. This difference in mortality rates was not due to a size difference in the prawns tagged, as might be expected, because the size range and average size of the school prawns tagged was higher than that for king prawns.

Initial tagging mortality could probably be reduced by circulating cooled water in the holding tanks during experiments. Neal (1968) has held shrimp for marking experiments, at a temperature 3 to 5°C. lower than the water from which they were taken, "thus reducing their metabolic rate and increasing survival". Water salinity had no apparent effect on the initial tagging mortality (Table 1). The school prawns tagged in these experiments had carapace lengths ranging from 14 to 31 mm., the smallest one recaptured had a carapace 16 mm. long when released. Tagged king prawns had carapace lengths from 13 to 35 mm., the smallest recaptured had a carapace length of 18½ mm. when released. A chi-square test applied to the 2×2 contingency table comparing the recapture rates of large and small ($CL \geqslant 22$ mm. and $CL \leqslant 21$ mm. respectively) male and female school prawns in experiment 5 revealed no significant differences in the rate of recapture. A chi-square test indicated a significant difference in the recapture rates of large and small king prawns ($CL \geqslant 23$ mm. and $CL \leqslant 22$ mm. respectively, sexes combined) in experiment 4 but unfortunately this test remains inconclusive because of the small number of prawns recaptured. All the prawns in these experiments were of sufficient size to be retained by prawn fishing nets and mesh selectivity would not account for the higher recapture rate of the larger king prawns in experiment 4.

Lindner and Anderson (1956) and Iversen and Jones (1961) reported that the percentage of shrimp recovered was greater for the larger shrimp than for the smaller ones. A small number of school prawns in experiments 2, 3 and 4 left the Hunter and Clarence Rivers and were recaptured up to 7 miles north of the river mouth in depths to 8 fathoms. (The existing fishing grounds in the Hunter and Clarence regions are situated north of the river mouth.) The majority, however, were soon recaptured in the river a few miles downstream from the release point. The school prawns released in Stockton Bight were recaptured up to 163 days later, in Stockton Bight, north and south of the release point in depths to 17 fathoms. This record of 163 days of freedom by an adult male school prawn (20 mm. carapace length at release) was noteworthy because the average lifespan of this species is considered to be less than 1 year (Racek, 1959; Ruello, unpublished data). Nearly all of the king prawns released in Newcastle Harbour were recaptured in the river within a few weeks of being released. Five were recaptured east and northeast of Newcastle at depths ranging from 37 to 45 fathoms, at least a month after release. Experiment 2 in the Hunter River provided the highest growth estimates obtained in these studies, the average increase in carapace length (of school prawns) was 0·1 mm. per day. The largest individual growth was

* This is the percentage of prawns found injured or dead in the two-hour holding period before release.

recorded from a female school prawn whose carapace length increased from 18½ to 28 mm. in 61 days. (This is equivalent to an increase in total length of approximately 38 mm.) These growth estimates compare favourably with those obtained from length frequency studies in the natural populations (Ruello, unpublished data).

Seven per cent of all tagged prawns returned showed negative changes in carapace length of 1 mm. or more. These decreases could be due to observational errors, but in most cases they would represent negative growth. Lindner and Anderson (1956) had 6·2 per cent of white shrimp returned from the north-central Gulf of Mexico with equivalent negative changes in total length (their table 5, pp. 564–565). In addition to evidence of growth and the characteristic inshore-offshore migration of penaeid prawns, a case was recorded where a tagged female school prawn had mated after release. Three school prawns also showed considerable development of the ovaries during their period of freedom. Valuable data was obtained from these tagging studies despite the small number of prawns released and the limited fishing effort expended in New South Wales, particularly in ocean waters.

Conclusion

Evidence has been presented which shows that penaeid prawns bearing Atkins tags can grow, mature, mate and carry out their characteristic inshore-offshore migration. Although the adverse effects of the application of an Atkins tag are not known this tag is nevertheless an obvious improvement over the Petersen disk tag, particularly for the smaller sized animals. The Atkins tag is extremely light, does not interfere with the movements of prawns, apparently inflicts little physical damage to the animal and can be effectively used in the recognition of individual prawns for population studies.

Addendum

A tagged male king prawn released in the Hunter River at Newcastle in January 1969 (Experiment 4) was recaptured 368 days later, approximately 400 nautical miles north of the release point, at a depth of 57 fathoms due east of Cape Moreton, Queensland. The prawn had increased 12½ mm in carapace length from 27 to 39½ mm. between the time of release and recapture. The recovery of this king prawn was the first evidence of extensive migration of penaeid prawns along the east coast of Australia and provided invaluable information on the age and growth of this species. Lindner and Anderson (1956) recorded a migration of 360 miles in a white shrimp (*Penaeus setiferus*) tagged with a Petersen disk tag and the longest time between release and recapture of another white shrimp as 257 days.

Acknowledgements

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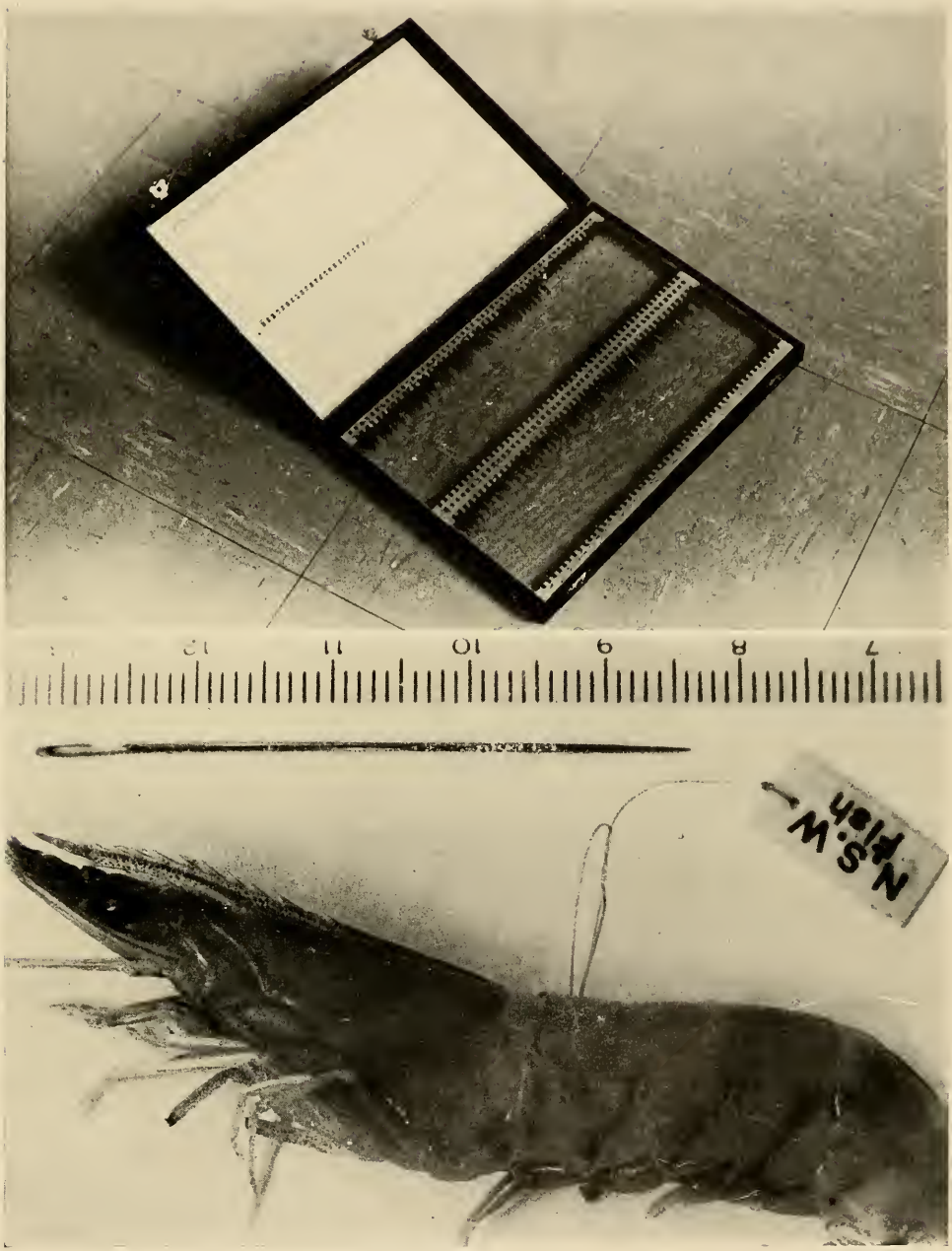
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